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TRAINING AND EDUCATIONAL PAPER

Eighth grade students become proficient at CPR and use of an AED following a condensed training programme☆

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Summary
Objective: To evaluate a new, 1-h, condensed training programme to teach continuous chest compression cardiopulmonary resuscitation (CCC-CPR) and automated external defibrillator (AED) skills to a cohort of eight grade public school students.
Methods:
Study design-prospective, interventional trial;
Study population-convenience sample of students from two eighth grade classes;
Study setting-urban, public school;
Study protocol-written parental consent was obtained. Student attitudes, prior experience and baseline knowledge were sampled using an initial questionnaire and a modified American Heart Association (AHA) CPR/AED pretest. Students received training in continuous chest compression CPR (CCC-CPR) and AED use through a new condensed training programme. Student CCC-CPR and AED skills were immediately tested in a standardized fashion by the study team. Four weeks later, written and practical examinations were retaken by the same students supervised by the study team. Examination score differences were analyzed using matched pair *t*-tests. All tests were two tailed with alpha set at 0.05. Confidence Intervals (CI) 95% were calculated as appropriate. The primary outcome measure was the percentage of students who could correctly perform CCC-CPR and application/operation of an AED in a mock adult cardiac arrest scenario.

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Results: Thirty-three eligible subjects completed the programme; mean age 13.7 years; 48.5% female. Eight participants reported some prior training in CPR and AED use. Following initial training, 29/33 (87.8%) subjects demonstrated proficiency at CCC-CPR and AED application/operation in a mock adult cardiac arrest scenario. At four-weeks, 28/33 (84.8%) subjects demonstrated skill retention in similar scenario testing. Subjects also showed improvement in written knowledge regarding AED use as shown by scores on an AHA based written exam (60.9% versus 77.3%; $p < 0.001$).
Conclusion: With our focused, condensed training program, eighth grade public school students became proficient in CCC-CPR and AED use. This is the first study to document the ability of middle school students to learn and retain CCC-CPR and AED skills for adult sudden cardiac arrest victims with such a curriculum.

Introduction

Sudden Cardiac Arrest (SCA) is a leading cause of death, claiming approximately 300,000 lives each year in the United States.[1] Outcome after SCA is dependent on critical interventions; particularly effective chest compressions, early defibrillation, and advanced life support (AHA Scientific Statement 2004).[2] With current health care delivery systems in place, survival to hospital discharge remains extremely poor with estimates at or below 5%.[2] In many of the nation's largest cities, neurologically intact survival is as low as 1%.[3]

The reasons for the dismal survival rates are many but two major contributing factors are the lack of bystander initiated CPR, and the apparent underuse of AEDs by the lay public. Both of these have been clearly documented in the state of Arizona through instituting a statewide cardiac arrest and AED registry termed the Save Hearts in Arizona Registry and Education (SHARE) Program. The lack of bystander initiated CPR can potentially be overcome in Arizona and globally by teaching chest compression only, or continuous chest compression CPR (CCC-CPR). Chest compression only CPR has been shown in animals to be dramatically better than no bystander CPR and even better than CPR with mouth-to-mouth rescue breathing when chest compressions were interrupted for a realistic 16 s for rescue breathing.[4] A recent abstract from the KANTO area of Japan involving 4241 witnessed out-of-hospital cardiac arrests reports statistically improved survival with bystander chest compression only CPR versus chest compression CPR with ventilation.[5] Secondly, while AEDs have been shown in a variety of settings to improve survival when used by certified trained individuals, lay individuals rarely use them.[6] Both of these major problems could be overcome if citizens were taught bystander chest-compression-only CPR along with the use of AEDs.

Because time to defibrillation remains a critical element in a successful resuscitation, the automated external defibrillator (AED) was developed to broaden the pool of available rescuers. The addition of AED training to CPR training in lay volunteers has been shown to produce superior survival compared to conventional CPR training alone.[7] Several studies have even demonstrated that very young previously untrained children can be taught to successfully operate an AED.[8,9]

Education and public participation, however, remain the cornerstones in promoting and developing a successful public access defibrillation (PAD) programme. With a ready pool of young potential rescuers available in our public schools, we sought to develop a new condensed CPR/AED curriculum that could easily be incorporated into public school education.

For the purpose of our present study, we developed a 1-h, condensed AED/CPR training programme addressing the most common victim of cardiac arrest, the adult. Subsequently, we conducted a prospective investigation to test the hypothesis that a sample of eighth grade students would demonstrate and retain proficiency at continuous chest compression (CCC)-CPR and AED use after administration of a condensed, 1-h, training programme at their school during classroom hours.

Methods

Study design

This was a prospective, interventional investigation.

Study setting

The study was conducted at Madison Meadows Middle School located in Phoenix, Arizona. The school

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is located in a suburban neighborhood of generally middle class families. Phoenix Children's Hospital (Phoenix, Arizona) served as the study's sponsoring institution and its IRB approved the protocol prior to study initiation.

Study population

The Madison Meadows Middle School was chosen as the site of the study due to its reputation as a strong public school within a major metropolitan area. The school's racial and ethnic profile is as follows: Caucasian 78%, Latino 14%, African American 3%, Native American 3%, and Asian 2%. All who enrolled completed an initial survey. The participants represent two eighth grade classes chosen at random. Fifteen percent of students are eligible for free or reduced-price lunch programmes. Prior to participation, students were given parental consent forms describing the study and were offered the opportunity to ask questions.

Study protocol

Students whose parents provided written consent were enrolled in the study group. Only students who had parental permission and were available for both testing sessions were included in the study. Students completed a preliminary survey (Table 1) to sample pre-education attitudes and experience. Additionally, prior to any formal CPR/AED education, they completed a written pretest (Table 2) consisting of 10 AED/CPR specific questions taken from the American Heart Association (AHA) Heart Saver AED course. On the day of formal training, students received 50 min (one class period) of a combined lecture, skills demonstration, and hands-on practice. The topics of the lecture included a discussion of basic cardiac physiology, recognition of the signs and symptoms of cardiac arrest, and the elements of the AHA chain of survival. The hands-on demonstration introduced students to continuous chest compression CCC-CPR, the components

Table 1 Middle school student AED questionnaire

1. How old are you? 12____ 13____ 14____
2. Are you male or female? Male____ Female____
3. What is your race? Caucasian ____ African American____ Hispanic____ Asian____ Other____
4. Have you known anyone who had a Cardiac Arrest? Yes____ No__
5. Do you know what an Automatic External Defibrillator (AED) is? Yes____ No____
6. Have you ever seen an AED in a public place? Yes____ No_____
7. Have you had any prior CPR or AED training? Yes____ No____
8. Have you ever performed CPR? Yes____ No____
9. If a family member required CPR, would you perform it? Yes____ No____
10. If a stranger required CPR, would you perform it? Yes____ No____
11. I would be uncomfortable performing CPR because of (check all that apply):
    - Mouth to mouth breathing____
    - Fear that I might get an infection____
    - Fear that I might harm the patient____
    - Fear that I might get sued____
    - None of above____
    - Other_____
12. Would you be willing to perform CPR on a stranger if it did not require mouth-to-mouth breathing?

    Yes____ No____

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Table 2 Modified AHA, CPR/AED test

1. What is the correct order for the first 3 links in the AHA adult Chain of Survival?
a. Phone 911, give CPR, use the AED
b. Give CPR, phone 9111, use the AED
c. Phone 911, use the AED, give CPR
d. Give CPR, use the AED, phone 911

2. What are the signs of circulation?
a. Normal breathing, coughing, or movement
b. Slow, gasping, irregular breaths
c. Blue, cool skin
d. Universal choking sign

3. You see someone collapse. What is the first thing that you should do?
a. Check the victim's mouth
b. Check for response
c. Do the Heimlich maneuver
d. Give 2 slow rescue breaths

4. In correct order, what are the 4 steps for operating an AED?
a. Power on, attach pads, clear and analyze, and clear and shock
b. Attach pads, power on, clear and analyze, and clear and shock
c. Clear and analyze, power on, attach pads, and clear and shock
d. Attach pads, clear and analyze, power on, and clear and shock

5. On which victims below would you use an AED?
a. The victim moves but cannot cough forcefully or speak and lips are blue
b. The victim has pressure or pain in the chest
c. The victim has no response and no normal breathing or signs of circulation
d. The victim has sudden numbness or weakness in one arm

6. You turn the AED on and attach the AED pads to a victim who has no signs of circulation. The AED says ''no shock advised.'' What should you do next?
a. Press the ON button
b. Remove the AED pads
c. Give rescue breaths and chest compressions
d. Push the SHOCK button

7. The AED advises a shock for a victim who has no signs of circulation. Before pressing the AED SHOCK button, what should you do?
a. ''Clear'' the victim and then push the SHOCK button
b. Perform 1 min of CPR and check the victim
c. Recheck signs of circulation and then shock the victim
d. Check pad position and then shock the victim

8. After 1 shock from the AED, you receive another ''shock advised'' message from the AED. What should you do?
a. Give chest compressions and breaths for 1 min
b. Turn off the AED and remove the AED pads
c. ''Clear'' the victim and push the SHOCK button
d. Turn the victim to the side position and leave the AED attached

9. After 3 shocks from the AED, the AED says ''no shock advised.'' You check for signs of circulation and find that there are no signs of circulation. What should you do next?
a. Give CPR for 1 min and follow the AED prompts
b. Turn off the AED and remove the AED pads
c. ''Clear'' the victim and push the SHOCK button
d. Roll the victim to the side position and wait for the EMS (paramedics)

10. After 2 shocks you receive a ''no shock advised'' message from the AED. The victim has signs of circulation, is breathing normally, and there are no signs of injury. What should you do next?
a. Give 4 cycles of 15 compressions and 2 breaths
b. Turn off the AED and remove the AED pads
c. Check the AED pads and press the AED ON button
d. Leave the AED attached and roll the victim to the side position

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of the Zoll AED Plus with Graphical Interface using CPR-D Padz and its operation. During the training we stressed that this form of CPR was specific to adult cardiac arrest victims and not intended for the pediatric arrest or drowning victim. In addition, we stated that the training was not designed to replace more comprehensive first-aid courses that were also strongly encouraged. We divided the students into two groups with each study author and worked through an adult cardiac arrest scenario. For testing, the students were separated during evaluation. Immediately following group training, each student's CCC-CPR and AED skills were randomly tested by a study team consisting of two of the study authors and two AHA certified CPR instructors. Each student was assessed using our standard checklist of critical skills. (Table 3). The students demonstrated their proficiency of critical skills necessary to perform CCC-CPR correctly, and apply and operate the same Zoll AED Plus in an adult cardiac arrest scenario. Four weeks later, with no additional training or educational reinforcement, we retested students at random with the same written test and practical examination by the study team. To accurately assess individual proficiency, students were physically separated from each other during testing.

Statistical analysis

We recorded the data on structured forms and entered in Microsoft Access for Windows (Microsoft Corp, Redmund WA). We calculated proficiency and score percentages, standard errors, and confidence intervals using SAS software, proc means. A comparison of testing results at the time of training compared to four weeks later was done. The primary outcome measure was the percentage of students deemed proficient at CCC-CPR and AED skills at the time of initial training and at the subsequent 4-week follow-up evaluation.

Results

There were 42 students who were eligible to participate in the programme. Of those, 33 received parental consent and completed the programme. The additional 9 students received parental con-

Table 3

S.H.A.R.E. AED/CCCCPR skills evaluation*

Name_____

Class_____

Activate EMS:	Yes_____	No_____
Check Responsiveness:	Yes_____	No_____
Initiate CCCCPR		
a. Proper Hand Position:	Yes_____	No_____
b. Proper Compression rate/depth:	Yes_____	No_____
AED		
a. Turns unit on:	Yes_____	No_____
b. Applies Pads properly:	Yes_____	No_____
c. Follows Voice prompts:	Yes_____	No_____*

* If No, what skill was neglected? _____

* Save Hearts in Arizona Registry standardized CCCPR skills checklist

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sent and completed the initial training. Regrettably they were never tested. They were, however, recaptured without further education and tested 4 weeks later. Subjects mean age was 13.7 years and 48.5% were female. Eight participants reported some prior training in CPR and AED use. Following initial training, 29/33 (87.8%) of subjects demonstrated proficiency at CCC-CPR and AED use in a mock adult cardiac arrest scenario. The majority, 25/33 performed all 7 skills correctly (75.7%), while 29/33 performed 6/7 skills correctly (87.8%). Following initial training, 28/33 (84.8%) demonstrated retention of skills and proficiency at CCC-CPR and AED use in a similar mock adult cardiac arrest scenario. In these evaluations, 25/33 performed 7/7 skills correctly (75.7%), 28/33 performed 6/7 skills correctly (84.8%). Of the 9 students for whom incomplete data exists, 7/9 (77%) demonstrated proficiency at CCC-CPR and AED use when tested at 4 weeks after the initial training. For all students, the skill most commonly omitted was ''calling all clear'' before administering the shock. This occurred 4/33 times initially and 2/33 times on follow-up testing. Additionally, 1/33 participants failed to activate EMS.

Subjects showed improvement in written knowledge regarding AED use as shown by improved average scores on a modified AHA Heart-Saver AED course written examination (60.9% versus 77.3%; $P < 0.001$). Survey results by question are summarized in Table 4.

Table 4 Middle school student AED questionnaire

1. Age: 13.7 years
2. Female: 48.5%
3. Race/Ethnicity: Caucasian 81%, Latino 9%, Other 10%
4. Have known anyone who had a Cardiac Arrest. 11/33 (33%)
5. Know what an AED is. 15/33 (45%)
6. Have seen an AED in a public place. 8/33 (24%)
7. Have prior CPR or AED training. 8/33 (24%)
8. Have performed CPR. 2/33 (6%)
9. If a family member required CPR, I would perform it. 27/33 (82%)
10. If a stranger required CPR, I would perform it. 24/33 (73%)
11. I would be uncomfortable performing CPR because of:
    a. Mouth to mouth breathing. 13/33
    b. Fear of infection. 8/33
    c. I might harm the patient. 15/33
    d. I might get sued. 6/33
    e. None. 8/33
12. I would be willing to perform CPR on a stranger if it did not require mouth-to-mouth breathing. 29/33 (88%)

Discussion

Because ventricular fibrillation remains the most common treatable rhythm in cardiac arrest, rapid access to defibrillation is critical to a successful resuscitation.[10] It has been stated that chances for successful defibrillation decrease by about 7–10% for every 1-min delay in delivering electrical counter-shock therapy for ventricular fibrillation.[2] Thus, any delay in treatment greatly reduces the chances for a successful resuscitation. Cities that have low survival rates have long delays from the onset of cardiac arrest to defibrillation. Therefore, the AHA has championed the concept of public access defibrillation as a method of strengthening the next link in the chain of survival. Public access defibrillation (PAD) refers to the use of automated external defibrillators (AEDs) by persons other than paramedics or traditional first responders such as police or firefighters.

Those responsible for developing the automated external defibrillator (AED) clearly understood the need for a rapid response and definitive treatment to a cardiac arrest victim. The promise of the AED has been recognized and described in the medical literature for nearly 20 years with successful application by first responders and a demonstrated reliability and simplicity that have allowed even children to successfully operate the device with minimal training.[8]

Although the potential benefit from AED use is clear, the willingness of our citizens to use these devices and participate in resuscitation activities remains uncertain. In our own State of Arizona, the Save Hearts in Arizona Registry (S.H.A.R.E.) was developed to formally catalogue and allow analysis of statewide cardiac arrest data. This registry data supports the belief that bystander CPR and AED use is a rare event. Within the State of Arizona, bystander CPR rates average approximately 30% with the quality of bystander CPR documented by EMS first responders often suboptimal. PAD system results are also disappointing. In fact, a review of the S.H.A.R.E. database (which includes 2500 AEDs in public locations across the state) during the 56 months between April 2001 and December 2005, revealed only 20 AED uses. This resulted in an average of 4.3 AED uses per year for the entire statewide PAD program. Ten of the AED uses were by off duty medical personnel and 10 by true laypersons. Only two uses during that time period resulted

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in successful outcomes. Even in cities with continual, intense training for laypersons, bystanders perform CPR approximately 50% of the time.[10]

Specifically in young adults, a recent survey of 638 high school students reported only 31.9% were willing to apply an AED consistently and only 43% to perform mouth-to-mouth resuscitation.[11] Our survey supports many of these same findings within the middle school student population. Students indicated a reluctance to perform mouth-to-mouth breathing, a concern for contracting infection, and a fear of harming the patient as some primary barriers to involvement.

Other barriers to conventional CPR/AED education include cost, convenience and a reliance on voluntary enrollment. An AHA CPR/AED course, in its present form, often relies on voluntary enrollment, requires time outside work or school, and has an accompanying monetary cost to the enrollee. A typical course may involve 4 h in the evening or on a weekend, limiting the potential for educating those individuals unable or unwilling to commit the time. Still to be determined are the necessary: (1) length of initial training; (2) frequency of retraining; (3) required content for training the public to use an AED; and (4) appropriate outcomes to be achieved through training.

In addition to these real life factors that led the study authors to sanction chest compression only (also called continuous chest compression,) CCC-CPR, for educating our students, there has been substantial evidence suggesting that the addition of mouth-to-mouth ventilation does not increase the chance of survival from adult cardiac arrest.[4,5,10,12]

A randomized trial has previously shown that survival after chest compression with mouth-to-mouth ventilation is similar to chest compressions alone and that chest compression alone may be the preferred approach for bystander inexperienced in CPR.[4]

Furthermore, present life-saving courses are often complex, with variable and sometimes confusing treatment algorithms based on age. Such complexity could undermine the best intentions of a lay rescuer by causing confusion and ultimately inaction out of a fear of getting it wrong and causing harm to a patient. With potential for additional information overload, these courses now include additional topics such as stroke, pediatric AED use, and child/infant safety. While all such information is important, we believe resources should focus on the overwhelming majority of cardiac arrest victims, adults. Such focused education addresses the great majority of cardiac arrest victims, potentially simplifies the educational process, and reduces the burden of required knowledge. This education can serve as a foundation on which to add additional first aid training.

As study authors we see a rich pool of potential rescuers within our public middle school student ranks. Previous studies have already shown that even younger children can be easily taught CPR and AED skills.[8,9] The middle school population is an ideal group to learn CPR/AED skills as part of their public school training. Such public safety training can be inserted into a school's curriculum and carried out within a typical school class period, with minimal time impact on the students existing curriculum. If carried out on a larger scale, the potential exists to rapidly educate a large segment of the population and growing a population of trained and willing first responders.

Our study demonstrates that a new, 1-h, condensed CCC-CPR and AED training programme can be inserted into a public middle school curriculum with demonstrated skill proficiency and retention of skills 4 weeks later. With concerns for the costs associated with such education on a larger scale, we are in the process of an additional study to demonstrate that paramedic/fire personnel can effectively deliver this education using existing community resources.

Study limitations

Our study suffers from several limitations. These include small sample size, a narrow population demographics, and incomplete data collection. We chose the sample size based on the size of two eighth grade classes at the participating school within a specific class period. Our goal was to insert the CPR/AED training programme into a typical school day without disruption of the general curriculum for that day. Although we asked if prior to this study students had received any CPR and AED training, we did not verify what kind of training they may have had. The training took place in the school library but could easily have taken place in the gymnasium or cafeteria with a larger student group. The training involved a lecture/demonstration session with the entire group followed by a hands-on practice session in which students formed a line and went through the arrest scenario, returned to the end of the line and cycled through the scenario again. Each student had the opportunity to view their peers in scenario, learning through observation and critique, and cycling again through the scenario. A larger group could easily be taught using such a method with the primary limitation being physical space and separation of groups to optimize the teaching.

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The lack of diversity within our study population could also be considered a limitation to the application of our results to other study populations. The preponderance of Caucasian students may cause some to question the validity of our study results if applied to other racial/ethnic participants. This remains a fair concern and should be tested with other student groups.

Additional criticism of our study could be directed toward defining proficiency and a concern that the period chosen for reassessment may have been too short to demonstrate long term skill retention. We chose to define proficiency as the ability to perform the critical elements necessary to demonstrate confidence and skill at performing CCC-CPR and AED application/operation within the framework of an adult cardiac arrest scenario. Using this definition, a student could fail to perform a skills element and still not jeopardize the success of the overall resuscitation effort. The skill neglected in all but one case was failing to ''clear'' the patient when delivering a prompted shock. Given the debatable risk associated with this oversight when using biphasic defibrillation and the fact that some AED units may voice this command, this skills failure was felt to have a negligible effect on the overall assessment of proficiency. Only one student failed to activate EMS during the mock cardiac arrest scenario. This could be also considered a minor oversight, too, as the student could still demonstrate a mastery of CPR and AED skills.

Lastly, the choice to reassess students four weeks after initial teaching and testing was an arbitrary decision and made in an effort to work within the framework of the students' school year. Further study could employ testing at a later time to improve the assessment of long term retention.

Conclusion

With our focused, condensed training programme, eighth grade public school students became proficient in CCC-CPR and AED use. This is the first study to document the ability of middle school students to learn and retain CCC-CPR and AED skills for adult sudden cardiac arrest victims with such a curriculum.

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